Video capture optimization with latency estimation on TV Workstation

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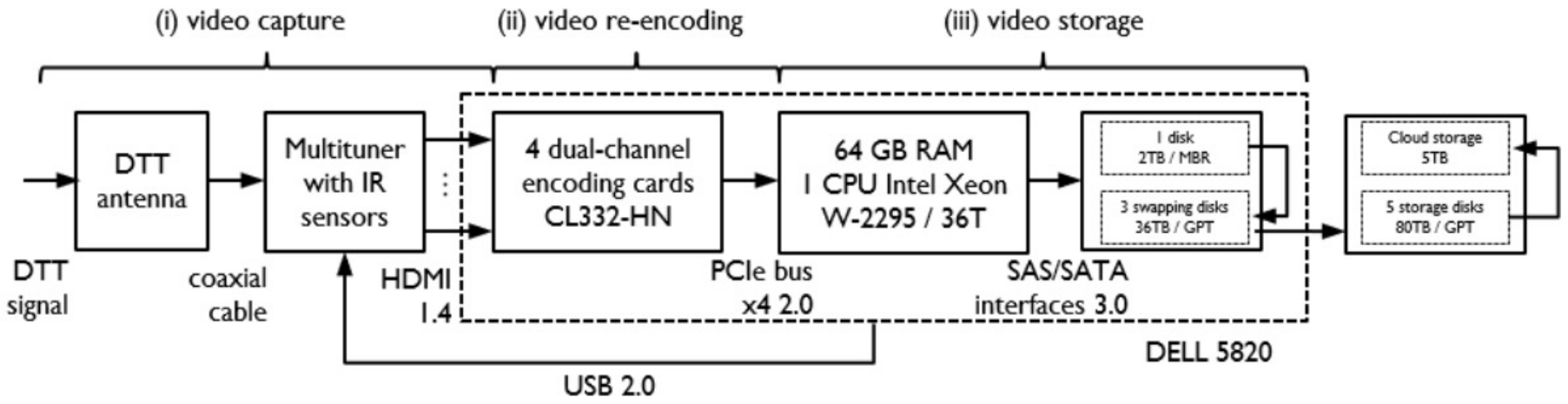
Outline

1. TV Workstation
2. The runtime for dynamic video capture
3. The algorithm to optimize the scheduling
4. Conclusions and perspectives

TV Workstation (1/4)

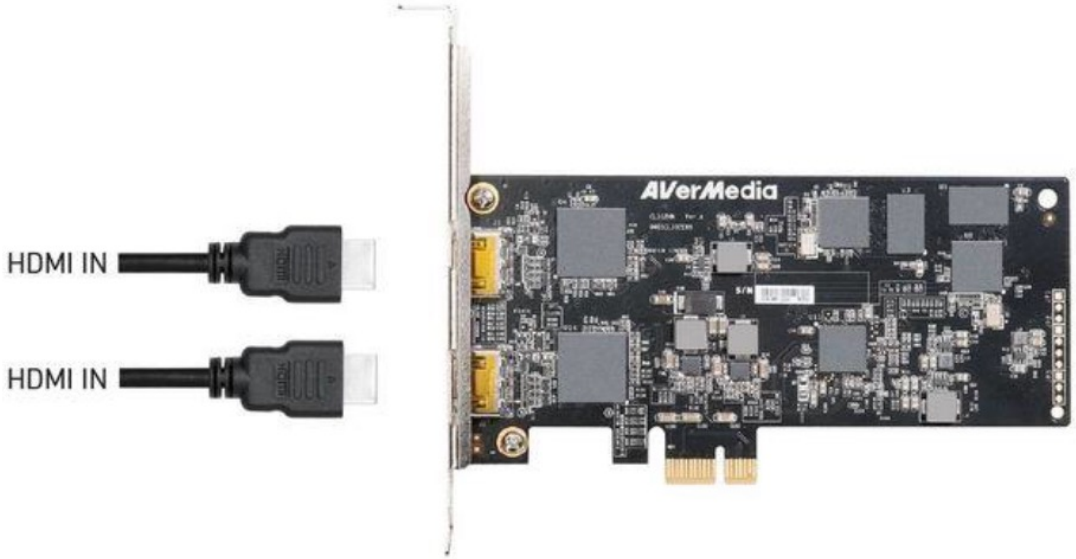
- DELL 5820 computer processes 9 disks and 120 TB of capacity for external storage (HD, 30 FPS, 24h/day), with real-time audio / video encoding, control of tuners with IR sensors

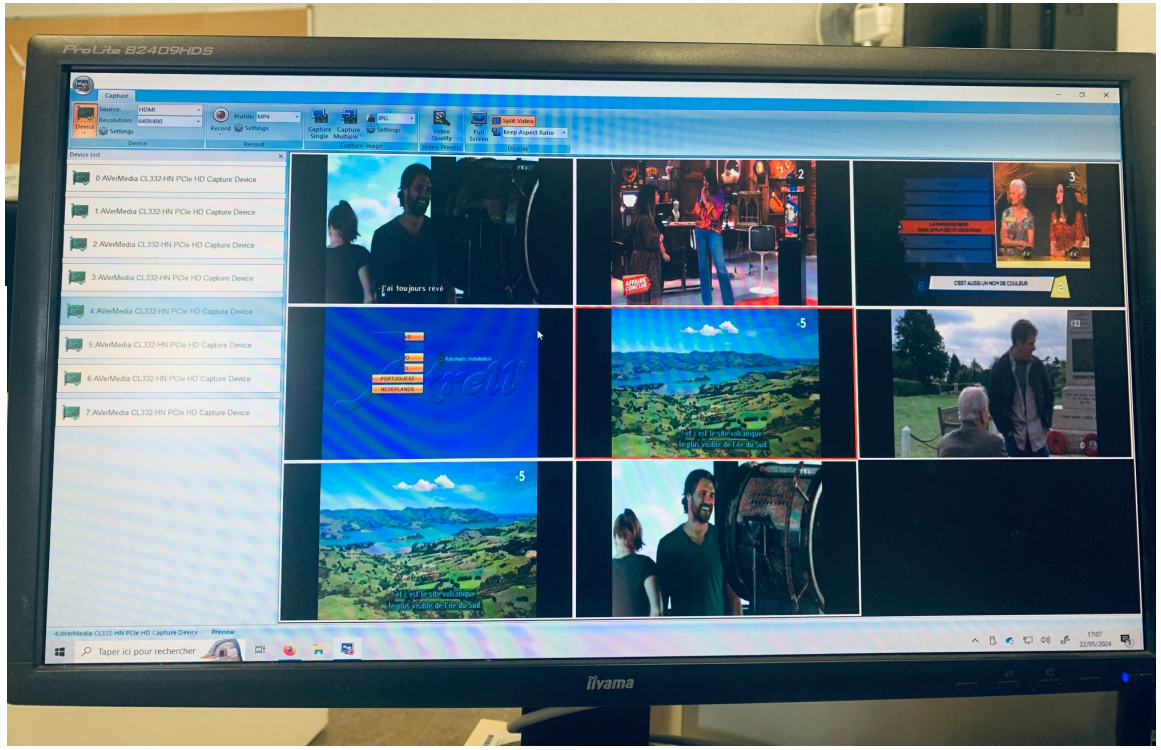


The architecture of the TV Workstation for video capture

TV Workstation (2/4)

- Avermedia :
  - Support Dual-Channel
  - Full-HD capture(1920 x 1080 30fps)
  - Hardware H.264 encoding
  - Standard HDMI connector





Avermedia CL332-HNPCIe HD capture device

TV Workstation (3/4)

- DELL 5820 computer performance for video storage

Resolution		Audio/ video		Video Mbps	TB/ month		Audio Kbps	GB/ month
HD	1280x720	asyn		3	7.23		256	621
SD	720x576			1.6	3.89		160	384
Low	320x240			0.56	1.36		128	308

TV Workstation (4/4)

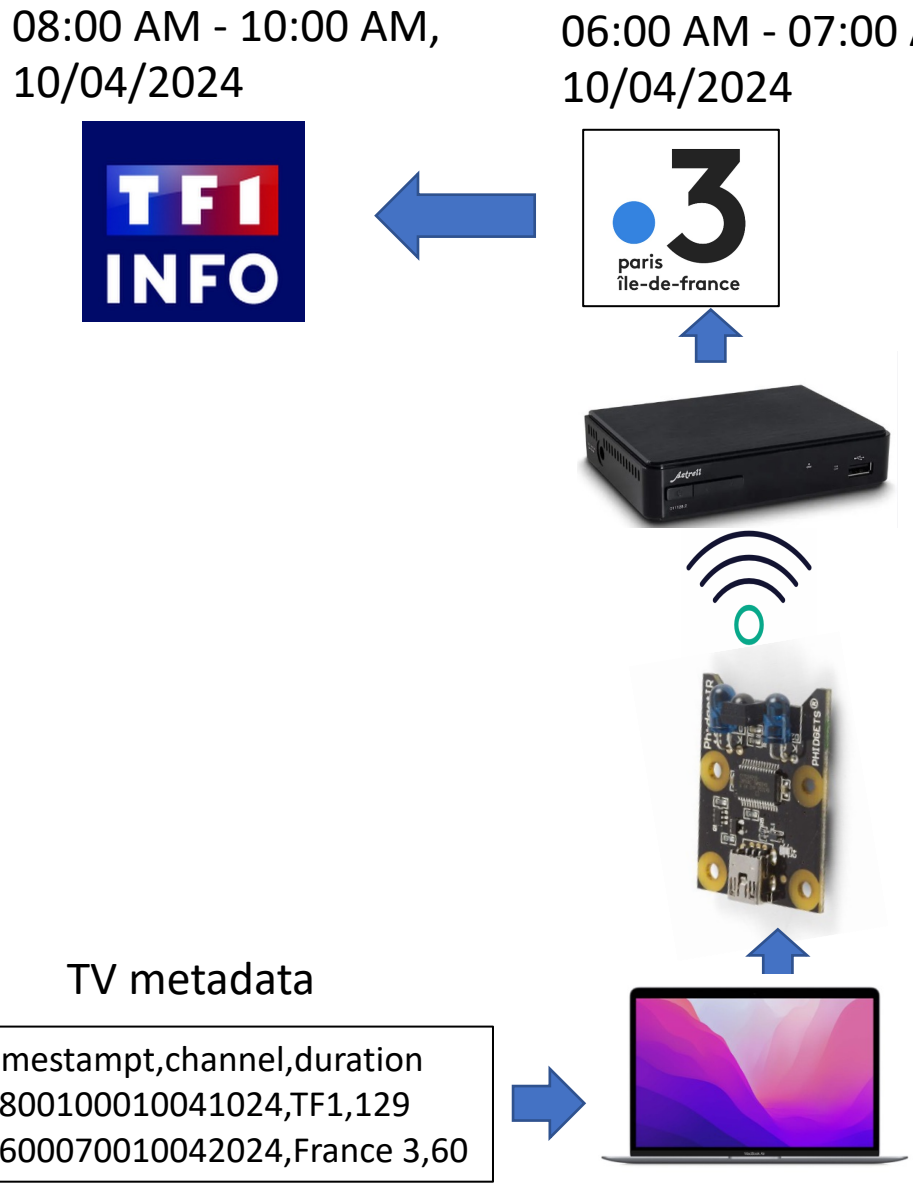
- we capture along in multiple channels with two modes.

Modes	Details	Pro	Cons
Static and continue capture	• Each input of card is assigned to a single channel with a static assignment (no switch between the channels during the capture). • The capture cannot be made idle.	Easy to setup	• No break, require long captures and a huge storage • Cannot filter the duplicate data (twice daily shows) • Can capture only 8 different channels.
Dynamic capture	• Each input of card can be controlled to switch between channels, even made idle for a time between two captures.	• Require short captures with a limited storage • Can capture many different channels at one time (>8) • Can filter the duplicate data	More difficult to handle

- Our solutions:
  - A runtime for dynamic capture
  - An algorithm to optimize the scheduling

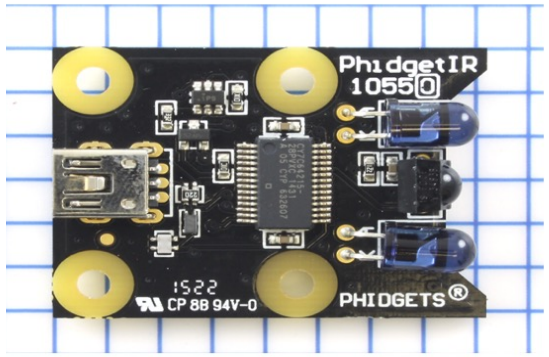
The runtime for dynamic video capture(1/4)

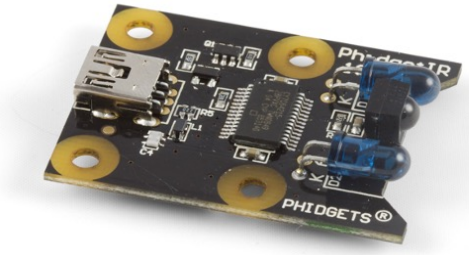
- We read TV schedule (csv file)
- We have developed a program tunning TV channels and Set channel switching time (T)
- Send the channel transmit code from the sensor to the Tuner at that time
- Switch TV channels automatically



The runtime for dynamic video capture(2/4)

- Phidgets sensor
  - Sensor (phidget IR 1055) : transmit signals
  - Hardware mounting kit : fixed position
    - 4x M3 Bolts (2cm Length)
    - 4x Plastic spacers (5mm Length)
    - 4x M3 Nuts
  - USB Mini-B : Connect the computer to the sensor



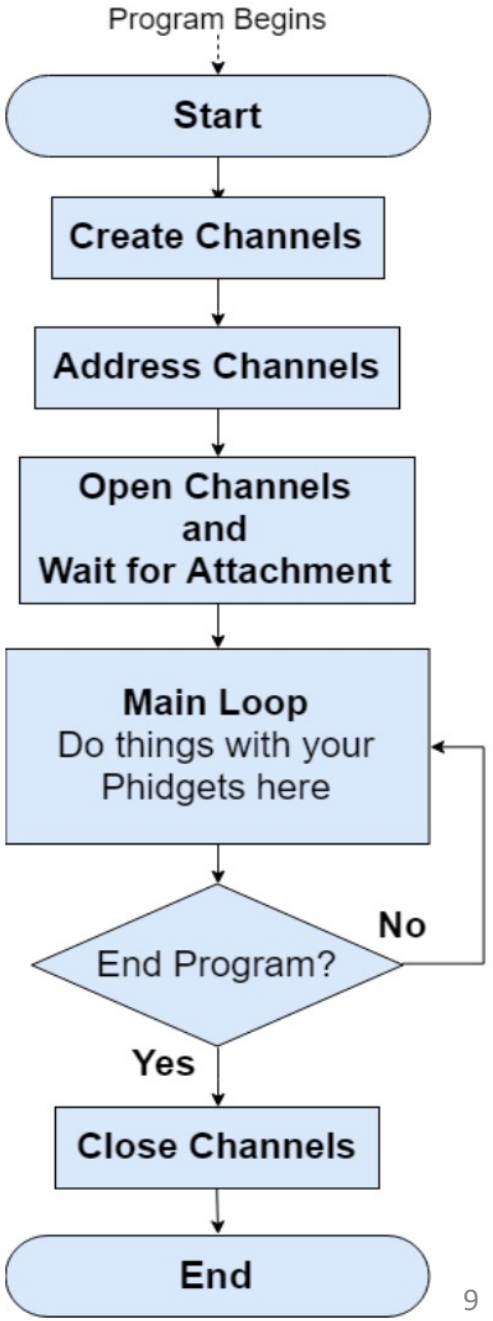


Phidget sensor

The runtime for dynamic video capture (3/4)

- Control phidgets sensor :

  - Every Phidget channel in any program will follow the same life cycle
  - Create channels
  - Set some basic parameters to indicate which Phidget to connect
  - Main loop : Switch channels …
  - End program



The runtime for dynamic video capture (4/4)

➢ A demo for single recording

- Input: A list of TV programs (illustrated in Tab 1)
- Output: A list of actions (sending a signal to the sensor, starting / stopping the record) correspond to a given timestamp. (shown in Fig. 1)

➢ Supplement steps

- Sorting the TV program list
- Defining the switching time as Equation

➢ Set channel switching time :

$$T = t1 + \frac{(t2 - t1)}{2}$$

- T : Switch time
- t1 is the stop_time of the current channel
- t2 is the start_time of the next channel
- Exception : The first channel, the channel switch time will be 1 minute before the start time

➢ The table follow the structure :

ch1; t0; t1

ch2; t2; t3

ch3; t4; t5

....

where t0 < t1 < t2 ..... < t7 and ch1 * ch2 ..... *ch4 (in a simple way, ch2 = ch1 +1)

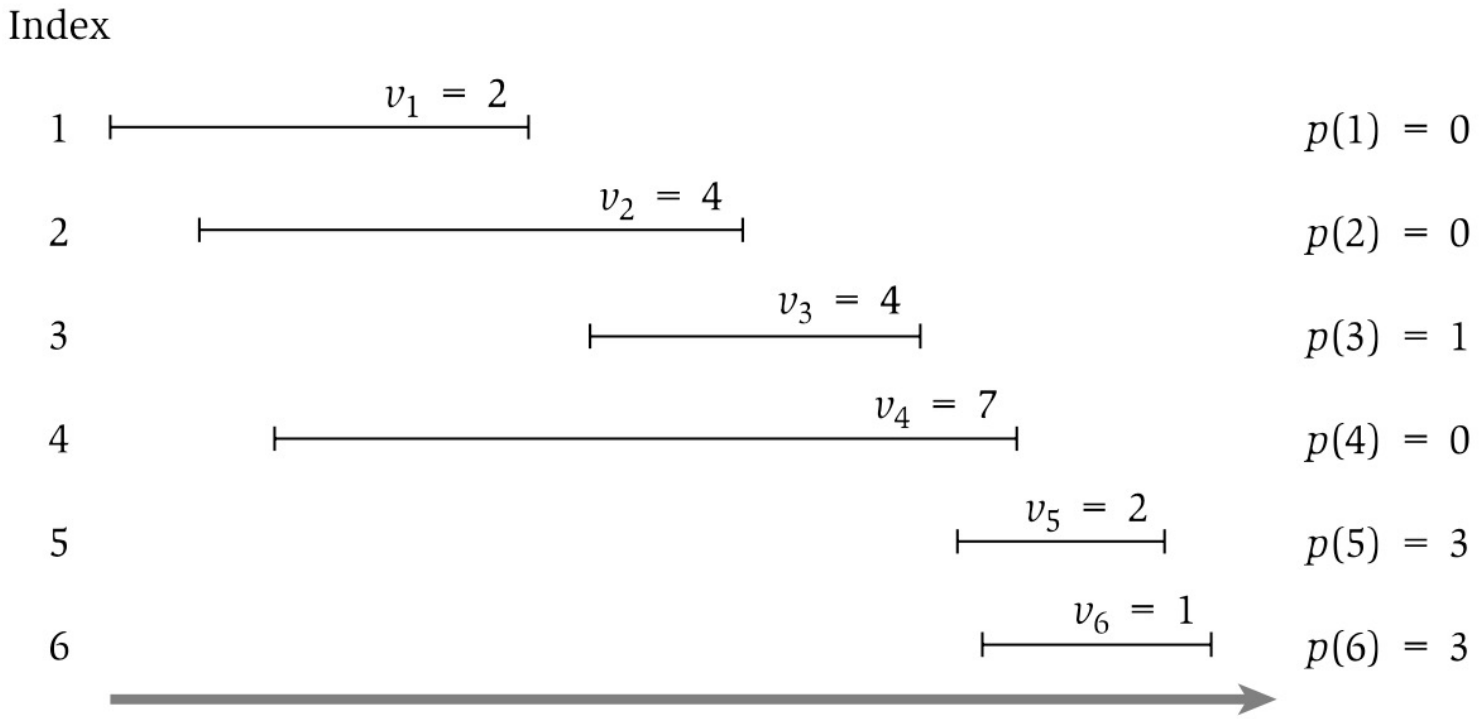
index	channel_name	start_time	stop_time
0	Channel 2	18:58:00	18:59:00
1	Channel 3	19:01:00	19:02:30
2	Channel 5	19:04:45	19:05:00

```
Starting ....
Total rows: 3
Time: 18:58:00
Switching to channel 2 at switch time 2024-05-23 18:57:00
Transmitted code 106F42BD for channel 2
Time: 19:00:00
Currently capturing channel: 3 at switch_time 2024-05-23 19:00:00
Transmitted code 106F827D for channel 3
Time: 19:03:30
Currently capturing channel: 5 at switch_time 2024-05-23 19:03:30
Transmitted code 106F629D for channel 5
```

The algorithm to optimize the scheduling (1/4)

➢ Kleinberg algorithm

- ➢ Input: A set of time intervals, each with a value (also called weight).
- ➢ Output: Subset of non-overlapping intervals with the largest total value.



An instance of weighted interval scheduling with the functions p(j) defined for each interval j.

The algorithm to optimize the scheduling(2/4)

- Kleinberg algorithm
  - Sort intervals by stop_time :
    - the intervals are sorted by their end_time using the quicksort algorithm.
  - Compute P value(P[j])
  - Compute the value M:
    - M[j] as the maximum value of the weighted sum of non-overlapping time periods when considering interval j .
    - Calculation formula:

$$M[j] = \max\{v[j] + M[P[j]], M[j-1]\}$$

    - v[j] is the value (weight) of interval j.
    - M[j-1] is the maximum weighted sum for intervals from 0 to j-1
    - M[P[j]] is the maximum weighted sum for non-overlapping intervals up to P[j].
  - Find solution:
    - Based on the M and P values, we can trace back to find the subset of time intervals that make up the optimal solution.

The algorithm to optimize the scheduling (3/4)

- We need to "correct" the algorithm.
  - Save the list of beginning(O)
  - Save the list of interval selected (S)
  - Save the list of remaining intervals(R)

$$R = O - S$$

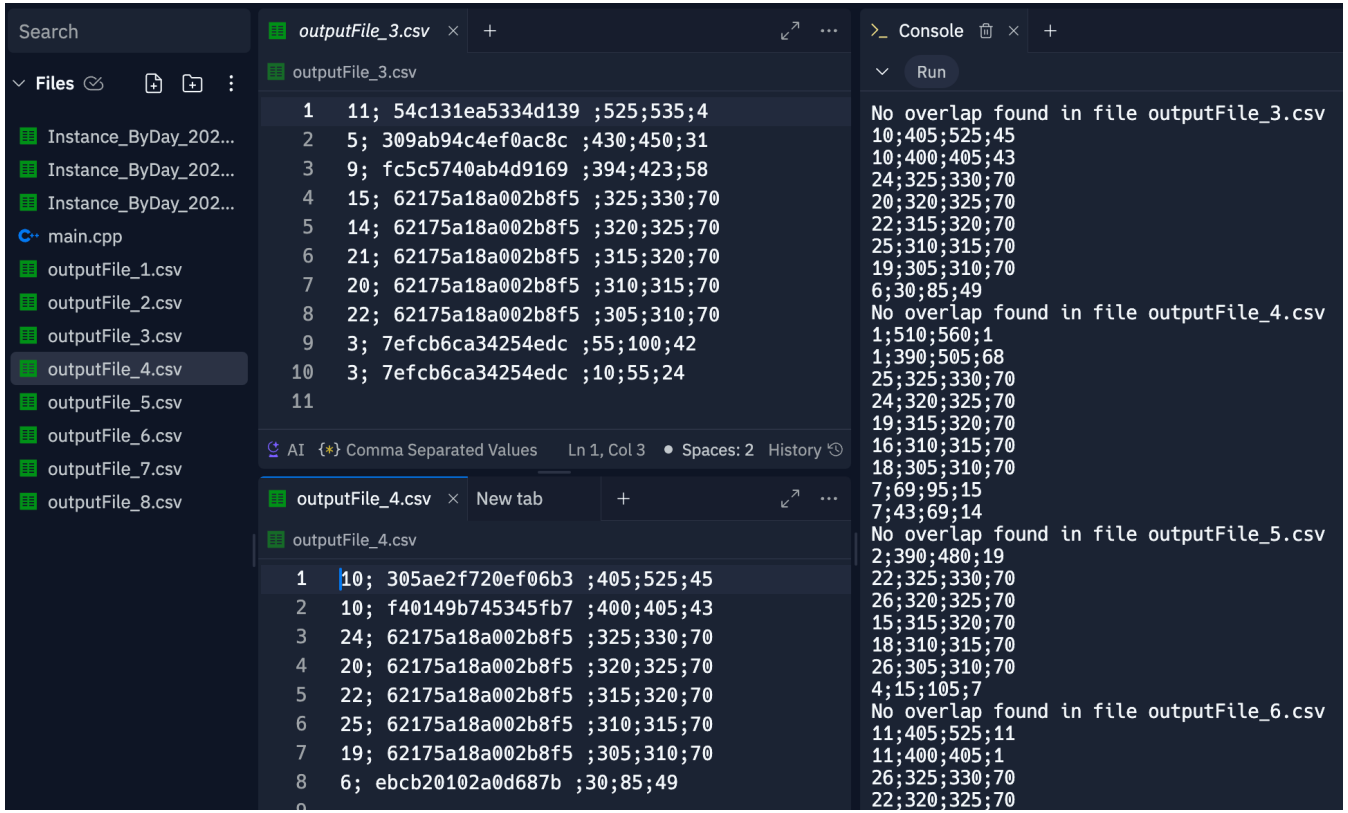
- In fact, we have to run the algorithm once .Then we have to remove the selected intervals
- after that then we re-run the algorithm a second time. And so forth, until we execute it a total of 8 times.

Number of cards	Number of reruns	Number of selected programs	Total weight after selection
4	1	19	95
	2	14	81
	3	10	71
	4	8	63
	total	51	310
6	1	19	95
	2	14	81
	3	10	71
	4	8	63
	5	9	54
	6	7	47
	total	67	411
8	1	19	95
	2	14	81
	3	10	71
	4	8	63
	5	9	54
	6	7	47
	7	7	40
	8	6	34
	total	80	485

Results of the Kleinberg Algorithm with Different Number of Cards

The algorithm to optimize the scheduling (4/4)

- we created a checker (check overlap)
  - The function can open the output_*. csv file, read them and check that an interval does not appears twice times.
- Through this iterative approach,
  - we ensure efficient utilization of all available resources
  - optimize the recording process across multiple machines



Results of checking overlap in the output

Conclusions and perspectives

- Conclusions:
  - We have developed a program auto switch channel
  - We have applied Kleinberg algorithm to optimize the interest of the recorded videos.
- Further Work
  - Improve the Kleinberg Algorithm Performance
  - Develop a stable video capturing program with automatic channel switching

THANK FOR YOUR ATTENTIONS !